five minutes after the meteor disappeared. According to the news from Fresno, the meteor left a track of great beauty, consisting of an irregular spiral curve, the lower end of which was little more than a tangle of threads. The upper part of this track was pale red, and farther down blue. The lower part was almost yellow, and still farther down were two detached bright red spots, like the sun breaking through clouds.—ED. NATURE.]

Height of Barometer.

MR. PEARSON will find much information as to extreme readings of the barometer in two papers published in the *Quarterly Journal* of the Royal Meteorological Society; one by Mr. H. Sowerby Wallis, in vol. viii. p. 147, and the other by Mr. C. Harding, in vol. xiii. p. 201. The lowest known reading is stated, on the authority of Mr. Blanford (NATURE, vol. xxxv. p. 344), to be 27·135 ins. observed on September 22, 1885, at False Point, on the coast of Orissa; this requires a subtractive correction of ·011 to bring it to English standards, reducing it to 27·124 ins. The highest known reading is given, on the authority of Prof. Loomis, as 31·72 ins. at Semipatalinsk, on December 16, 1877, giving an extreme range of 4·6 ins.

The lowest reading recorded in these Islands is 27·332 ins. at Ochtertyre, near Crieff, on January 26, 1884, while at Belfast the barometer fell to 27·38 ins. on December 8, 1886, and on the same day at Newton Reigny to 27·566 ins., which seems to be the lowest recorded in England. The highest pressures recorded in this country during recent years were on January 18, 1882, when 30·990 ins. was registered at St. Leonards, but on January 9, 1820, 31·056 was recorded at Kinfauns, Perth, and appears to be confirmed by other readings in Scotland.

HENRY MELLISH.

THE BRITISH ASSOCIATION.

BY the kindness of the Secretary of the British Association we were able to give in our last issue a list of the grants awarded by the General Committee just as we were going to press. Upon referring to this, it will be seen that the grants amount to very nearly £1100, that is £400 more than those awarded at the previous meeting. The increase of funds available for research is due to the large number who attended the Oxford meeting, the receipts being as much as £2175. In this matter, and indeed from every point of view, the meeting was a most successful one. The membership reached a total of 2321—a number greatly in excess of the average. In moving a vote of thanks to the authorities of the city for the hospitable reception accorded to the Association, Sir John Evans remarked that the meeting had been notable both for the large attendance of members and associates, and for the great scientific interest and importance of the papers read. In fact, it was the opinion of all that rarely, if ever, has a more brilliant meeting of the Association been held. No less than seventy-seven foreign members, eminent in many branches of scientific knowledge, honoured it with their presence. The exchange of ideas, which results from the meeting of investigators from all parts of the world, must lead to real progress. "Science," as someone has said, "is cosmopolitan." She recognises no differences of nationality between workers devoted to extending her domains. Therefore men who live "for the promotion of natural knowledge" meet on common ground at the British Association, for they know that anything that will help on this object will be appreciated.

Several changes in the constitution of the sections were adopted by the General Committee. Section D will in future be called Zoology instead of Biology, and there will be a separate section for Botany. Section I, which met this year for the first time, is to consist of Physiology, with Experimental Pathology and Experimental Psychology. As pointed out by Prof. Bayley Balfour in his address, Section D has had its constitution changed oftener than any other section of the Association. Experience will show whether the new arrangement is the one best calculated to bring together investigators with similar scientific interests.

The continual division of this section suggests that Astronomy should be removed from Section A (Mathematical and Physical Science), and have a section of its own. It may also be well to point out that there should be a sub-section of Section H (Anthropology) dealing with large questions of Archæology—that is to say, with Assyrian and Egyptian Archæology—and with the various points which, from an archæological point of view, are common to the earlier races.

Another matter worth the attention of the General Committee is the introduction of evening reunions of physicists and biologists, such as are provided in German meetings. Under the present conditions it is very difficult to meet and talk with fellow-workers, especially with foreign members, at each meeting.

The meeting will be held next year at Ipswich, under the presidency of Sir Douglas Galton, K.C.B., F.R.S. Liverpool will be the place of meeting in 1896. The Association was invited to meet in Toronto in 1897, but as arrangements are never made more than two years in advance, nothing definitely could be settled in the matter. There was a strong feeling, however, in favour of accepting the invitation when the proper time arrives for doing so.

The University testified to its interest in the welfare of science by conferring the degree of D.C.L. *honoris causâ* on the following eminent foreign investigators present at the meeting:—Prof. Edouard Van Beneden, Prof. Ludwig Boltzmann, Dr. E. Chauveau, Prof. Cornu, Prof. Theodor W. Engelmann, Prof. Wilhelm Förster, Prof. C. Friedel, Prof. L. Hermann, Prof. Gosta Mittag-Leffler, Prof. S. P. Langley, Prof. G. Quincke, Prof. E. Strasburger. The degrees were conferred by the Vice-Chancellor, and the Latin oration was delivered by Prof. Goudy. The following brief notes show the character of the recipients' chief researches:—

Edouard Van Beneden, Professor of Zoology and Comparative Anatomy, has not only contributed a long series of memoirs on the structure of various Invertebrata to the literature of zoological science, but has especially gained the highest recognition and esteem for his work on the microscopic details of the process of fertilisation in relation to karyokinesis and cell-structure. His investigations on this process in Ascaris megalocephala form the starting-point of recent theories and researches on the subject of the partition of the nuclear matter by the splitting of the chromosomes in spermatozoon and ovum and in the fertilised egg. In addition to these investigations, Prof. Van Beneden's researches on the formation of the blastoderm in the rabbit and the bat have been of the greatest importance, and are cited in all modern treatises as classical. Recently, Prof. Van Beneden has occupied himself largely with the study of Anthozoa (especially Cerianthus and its larva Arachnactis), and has arrived at most important conclusions as to the relationship of these forms to the Vertebrata.

Ludwig Boltzmann was born in Vienna in 1844, and is now Professor of Theoretical Physics in the University there. His first paper was on the distribution of electricity on a sphere and cylinder, and his second one on the mechanical significance of the second law of Thermodynamics. His subsequent papers are too numerous to mention in detail, and have been published principally by the Academy of Science at Vienna, and recently at Munich. The most important of these treat of the steady state of kinetic energy in gas molecules and its connection with the second law of Thermodynamics, of the specific inductive capacity of solids and gases, and other thermodynamic and electromagnetic subjects. Along with Clausius and Maxwell, he is a founder of the kinetic theory of gases, especially in its more complicated aspects and in its connections with the second law of Thermodynamics. Recently he has devoted himself to popularising Maxwell's electromagnetic theory in Germany.

French physiologists are represented by Prof. Chauveau of Paris. Two only of his achievements need be mentioned —his investigations of the movement of the heart, conceived in the same spirit, and pursued with the same desire to search out the secrets of nature that animated our own Harvey; and secondly, his inquiries as to the nature of the process by which infectious diseases are communicated from one individual to another. It would be difficult to estimate which of these is most worthy of our admiration, for whereas the first were experiments of light, the others were experiments of fruit, and served, with those of Pasteur and our own Lister, as the foundations of a new science—that of Bacteriology —pregnant with promise for the future welfare of mankind.

M. Cornu, Professor of Physics at the École Polytechnique, Paris, is renowned for his numerous experimental researches. His investigations on the velocity of light earned for him a high place among experimenters twenty years ago, and his work on the ultra-violet part of the solar spectrum is still the standard of reference. The telluric spectrum also, and the spectrum of hydrogen, have engaged his attention, as well as various problems in astronomical physics. But his investigations have not been confined to optical physics, one of the most important of them being concerned with the determination of the density of the earth. He was elected a Foreign Member of the Royal Society in 1884, and received the Rumford medal in 1878.

The career of Prof. Engelmann of Utrecht as an investigator has been very fruitful. His work, like that of Hermann, has related to the very *principia* of physiology—to those vital endowments which are common to ourselves and to organisms of the simplest structure. These he has studied with a view to the eventual solution of the most elementary, yet the most difficult, problems which living nature presents to the investigator.

Prof. W. Förster, the Director of the Observatory of Berlin University, is well known for his great activity in furthering astronomical inquiry, both in the institution under his charge and elsewhere. Quite recently he succeeded in establishing an International Bureau for undertaking and conducting astronomical computations. He has also played an important part in the work of the Geodetic Union. Most of his earliest work belongs to geodesy, a number of carefully-made pendulum observations calling for special mention. By directing attention to luminous clouds, and pointing out the importance of photographing and accurately observing them, he has done a service which will lead to results interesting alike to astronomers and meteorologists. His astronomical works, though not numerous, are such as add to his renown, and, with his rare and active administrative faculty, they single him out as well deserving the honour done to him.

Prof. Friedel, the eminent occupier of the chair of Organic Chemistry at the Paris Sorbonne, and one of the six members of the Chemistry Section of the Paris Academy of Sciences, has carried out numerous investigations of the highest value. His first work was on the relations between thermo-electric properties and crystalline form, but his chief researches relate to organic compounds, in the synthesis of which he has been very successful. A few of his earlier papers refer to the artificial production of minerals, and he has made some important contributions to the inorganic side of chemistry.

The name of Prof. Hermann of Königsberg is familiar to students of physiology in all parts of the world, as the author of a general treatise on the subject which has been translated into every European language. He is also the author of several monographs on special subjects, and of innumerable smaller papers, in each of which some permanent additions to knowledge are recorded. His investigation of the chemical processes which are concerned in muscular contraction, published a quarter of a century ago, and his more recent inquiries as to the electrical concomitants of these processes, constitute the foundation of what Physiology is as yet able to teach on these difficult but fundamental questions.

It was at the Allegheny Observatory, Pennsylvania, that Prof. S. P. Langley began his investigations in solar physics, which have resulted in so great an extension of our knowledge in this direction. About 1878 he turned his attention to the question of solar radiation. Finding the thermopile quite inadequate for the work he had undertaken, he was led to invent his now well-known bolometer, with which instrument he has since carried out some very important investigations. After the death of Prof. Henry, he was offered the position of Assistant Secretary of the Smithsonian Institution by Prof. Baird. He removed to Washington, but for a time continued to carry on his work at Allegheny. A few years ago, however, he built a small astro-physical observatory on the grounds of the Smithsonian Institution, and he has there continued and extended his work on the infra-red spectrum of the sun.

All mathematicians are familiar with the name of Gosta Mittag-Leffler, Professor of Pure Mathematics in Stockholm University. He is the editor of the authoritative journal *Acta Mathematica*, devoted to the extension of mathematical knowledge. His work in pure mathematics has been of a very varied character, the most noteworthy, perhaps, being concerned with linear differential equations and their integration, and with the theory of the uniform functions of a variable.

The Royal Society elected Prof. Georg Quincke of Heidelberg as a Foreign Member in 1879, for his researches in physics. He is one of the veterans of science, his first paper having been published so long ago as 1856. All branches of physics have been benefited by his careful experimentation and acute reasoning. Few workers, indeed, can claim to have added so much as he to our knowledge of physical laws, or to have studied natural phenomena in a more comprehensive and profound manner. His researches on capillarity, carried on thirty-seven years ago, led up to the important work in which he showed that the movements of amœbæ and protoplasm can be fully explained by physical laws.

Prof. Strasburger is Professor of Botany in the University of Bonn, having previously been Professor in the University of Jena. He is a Foreign Member of the Royal Society. Having made his mark in Morphology by his monumental work on the Gymnosperms ("Die Coniferen und Gnetaceen," 1872), he has since chiefly devoted himself to the study and investigation of the nucleus of the cell, with special reference to the reproductive processes of plants in their connection with the phenomena of heredity. His researches fill several volumes, such as "Zellbildung und Zelltheilung," "Angiospermen und Gymnospermen," "Unters. ueb. d. Befruchtungsvorgang," and his recent "Histologische Beiträge." It is not too much to say that to Prof. Strasburger's researches is due nearly the whole of our present knowledge of the processes of cell-division in plants.

SECTION I.

PHYSIOLOGY.

OPENING ADDRESS BY PROF. E. A. SCHÄFER, F.R.S., PRESIDENT OF THE SECTION.

BEFORE beginning the subject matter of my address I had conceived it to be necessary, appearing before you as we do as a new Section, to offer some sort of apology for our presence. But, on looking up the history of the Association, I find that my task is somewhat different. If I have any apology to offer at all it is that the Section of Physiology has ceased to appear for many years.

The British Association was founded at York in 1831; and at the subsequent meeting, which was held in this very city of Oxford, amongst other Sections which were established, was one for Anatomy and Physiology. Now, when we consult the records of this Section we are struck with the fact that Medicine early shows a marked preponderance. Thus, in 1833 a physician is selected as President for the Section, with two surgeons as secretaries; one of them, be it noted, being Mr. Paget. This preponderance soon came to be recognised in the designation of the Section, for in 1835 we find it entitled Section E, Anatomy and Medicine.

As time went on the interests of medical men became gradually more absorbed in the rapidly growing British Medical Association; and in 1841 the medical title was dropped, and the Section came to be called simply Physiology, which title it retained until 1847. Under that designation the Section has now been revived.

The fact that Physiology as a separate section in this Association was allowed to lapse for so long a period is not remarkable when we remember that during the first half of this period Physiology as a science was practically non-existent in this country. The teachers of Physiology were, almost without exception, practising physicians and surgeons, and even when a professor was expected to devote the whole of his time to the teaching of Physiology he was not expected to devote part of that time to the prosecution of physiological research. During all these years, from 1833 to 1847, we do not find amongst the officers of the Section any actual working physiologists. Most of the officers were distinguished medical men, with an anatomist here and there amongst them. Far be it from me to say that there was no actual work being done in Physiology at this time; for Charles Bell and Marshall Hall were engaged in elucidating the functions of the nervous system; whilst Bowman, Wharton Jones, and others were producing good and permanent work in various other departments of Physiology. Their labours, however, were isolated, and formed but oases in the Sahara of neglect into which the pursuit of Physiology had fallen in this country; and this during a period when it was being pursued with signal success and activity both in Germany and France.

After 1847 a revival of Physiology began to manifest itself even here; and this was followed by the establishment, from time to time, of a sub-section to Second D, which was devoted to Physiology, and had a special President. Whether, however, owing to their subordinate character, or from some other reason, these sub-sections had not usually any great measure of success, and for the last twelve years they have been wholly dropped. During that period Physiology has only twice been represented in the chair of Section D, and has usually had no secretarial representation. This decadence of Physiology in the British Association during the last eleven or twelve years is the more remarkable because it is obviously not due to any want of outside activity in regard to the subject; for during this period we find an extraordinary revival of interest in physiological research, a revival which in its most active stage dates from about twenty-five years ago, but still some twenty or thirty years later than the corresponding revival in France and Germany. I have taken the trouble to prepare a list of prominent physiological workers who flourished during the thirty years prior to 1870. My list comprises, in all, thirty. Of these four are English, five French, and twenty-one German or Dutch. Of the four English working physiologists not one is a teacher of Physiology. Of the five French and twenty-one German all are recognised teachers. It was not, in fact, until it came to be understood that teaching and work in Physiology, as in all branches of science, ought in the main, to be successful, to go hand in hand, that the science had any possibility of revival.

Let us glance for a moment at the history of the revival of Physiology in this country as compared with its revival in Germany. In each country the revival may be said to have been largely due to the influence of one teacher. In Germany the teacher was Johannes Müller; in this country, William Sharpey. Both of these remarkable men were pupils of Rudolphi, who was professor of Anatomy and Physiology in Berlin until 1833. It is stated regarding Rudolphi that "he was an enemy to subjective speculation in biological science: he looked on the so-called philosophy as mistaken and futile in its application to the phenomena of the animal economy, and based his physiology chiefly, and perhaps rather exclusively, on the study of the animal structure." The influence of Rudolphi is apparent in both Müller and Sharpey.

Müller was born in 1801, Sharpey in 1802; they were therefore of about the same age. But Müller's scientific and intellectual development was more rapid than that of his contemporary. Thus we find that already in 1826, when he was but twenty-five years old, Müller attained so great a reputation as to be made Professor Extraordinary in the University of Bonn; and before very long he was promoted to the grade of Ordinary Professor there. In 1833, whilst still a young man, he was called to the chair of Anatomy and Physiology at Berlin, which had just become vacant by the death of his master and friend, Rudolphi. Sharpey, on the other hand, occupied himself until 1829 with perfecting both his general and his special anatomical education. It was not until 1830 that he published his first essay in anatomical and physiological research entitled "On a Peculiar Motion excited in Fluids by the Surfaces of Certain Animals"—observations which were preliminary to the discovery of the existence of cilia in vertebrates. And it was not until 1836 that he was called to the newly instituted professorship of Anatomy and Physiology in University College, London, which he filled for so many years with such signal success. Both of these distinguished men owed, there is no doubt, their success as teachers of Physiology to their early anatomical training. The general anatomical bent of Johannes Müller is evidenced by the fact of his scientific work being turned so much in the direction of comparative Anatomy and Physiology. And Sharpey, although great, and deservedly great, as a teacher of Physiology, remained to his dying day, above all, an anatomist. Physiologists of this school are rare at the present day; but it is probable that in some respects the progress of Physiology may suffer thereby. Helmholtz began his public career as professor of Anatomy; but it would be unfair to attach too much weight to this particular incident in the case of so many-sided a man as the great Berlin Professor of Physics. Nevertheless, the necessity of a close and careful training in Anatomy for those who are afterwards to work at or to teach Physiology is so important that I do not hesitate to say that the younger physiologists who neglect the study of Anatomy will find that before very long they must abandon the pursuit of many byways of Physiology which might otherwise be followed up with manifest advantage.

The influence of Johannes Müller upon the revival of the pursuit of scientific Physiology in Germany, and indeed generally, cannot be over-estimated. We have only to look at the names and eminence of his pupils in order to recognise the immense influence which his teaching has exerted upon the progress of Physiology ever since his time. Some of these pupils are still amongst us, others have joined the majority. But the pupils of these men, again, are now great names in many departments of our science, and through them we cannot fail to recognise the influence which was exerted by this truly great man.

We may say the same in almost identical words of William Sharpey. The practical pursuit of Physiology in this country has mainly radiated from the centre where Sharpey taught. Michael Foster was his pupil. The physiological investigations of Burdon-Sanderson were assisted and encouraged by him. From Sharpey, therefore, we may trace the rise of the great school of Physiology at Cambridge, and we have only to look at the magnificent laboratory which has been erected here to observe a monument of the influence of the same teacher. And there have emanated either directly from the physiological school established by Sharpey at University College, or indirectly from those at Cambridge and Oxford, many of the most active teachers and workers in Physiology in the kingdom.

In these respects there is much in common between the revival of Physiology in Germany and in this country. In other respects, however, the two cases have been entirely under different conditions. There its revival, in common with that of science generally, has been assisted and stimulated by the active and beneficent co-operation of every German State. Here, also, in common with science generally, it has had to make its way against every conceivable obstacle; and almost without assistance, either moral or material, from the Government or from public bodies. But not only has it not met with assistance, there have been actual obstacles placed in the way of teaching and work in Physiology. Some have been unintentional, others intentional. As an instance of the unintentional may be mentioned the practice which has obtained in medical schools and on examining boards—a practice which, I am happy to say, is gradually being discarded—of appointing as teachers and examiners in Physiology men who may have a good general knowledge of the science, yet with whom it is not the business of their lives; and who cannot, therefore, be expected to be as familiar with its details, and absorbed in its interests, as those who devote their entire time and attention to its pursuit.

The more virulent opposition, in some measure, to science generally, but in the greatest measure to Physiology, appeared almost simultaneously with the active revival of the subject. This opposition, which has come to be known as the Anti-vivisection Movement, but which might equally well be called the Anti-scientific Agitation, has hitherto met with no measure of success, except that it has to a certain extent hampered the full development of the science by diverting to its defence some of the energy which might be devoted to its pursuit. Indeed, the actual results of this unreasoning agitation furnish an illustration of the old-established principle that persecution of a good cause will in the long run tend towards its development and propagation. And in this case the chief results have been the following:—

(1) The most immediate effect of the anti-vivisectionist attack was the establishment of the Physiological Society, which in the first instance was only a small gathering of working physiologists, who met to discuss measures of defence in a drawing-room in Queen Anne Street. This society, which had such a small beginning, is now large and important. Its doors are besieged by applicants for admission, although it is a necessity for such admission that the applicant be either a teacher of Physiology or a worker at Physiology, or both. Its numerical strength has grown from ten to fifteen to more than 150; and its numbers are every year increasing. And, besides the work which it has done in this country in promoting the interests of Physiology, and co-operation between English physiologists, it has succeeded in establishing a succession of triennial International Congresses of Physiology, which are amongst the most successful of such gatherings, and which have been the means of bringing us into communication with the most prominent physiological workers and teachers on the continent.

(2) A second result of the agitation was the passing of the so-called Cruelty to Animals Act. This Act, which was intended to restrict the performance of experiments upon animals, was in no sense called for, since it had been found by a Royal Commission that there was no evidence to show that there had been unnecessary experimentation upon animals, or any desire on the part of physiologists to neglect the use of anæsthetics. On the other hand, it is of inestimable advantage in that it gives the public a definite guarantee that the excesses of which physiologists used to be freely accused are not possible. Such excesses never did actually occur; although, to believe all the publications which have been issued by Anti-vivisection Societies, one would come to the conclusion that a physiologist is a being who spends his whole time in torturing sensitive creatures, careless of the suffering which he may cause, or even of the scientific results which he may obtain. The fanatical supporters of the agitation would have you to believe that we are all neither more nor less than "fiends"; they cry with Ferdinand that "hell is empty and all the devils are here."

I am told there was even a feeling of this sort in this University at the time when it was proposed to establish the Wayneflete Professorship of Physiology, and that an agitation was set on foot having for its object, first, the prevention of the establishment of such professorship; and secondly, that being impossible, the prevention of the professor's practising physiology. The common-sense of the University stifled this agitation, and the more intimate acquaintance with physiologists, which has resulted from the establishment of the school, has been sufficient, I believe, to smother the little fire which was still left smouldering.

(3) A third result of the Anti-vivisection Agitation was the establishment of the Association for the Advancement of Medicine by Research. This immediately followed a unanimous resolution of the International Medical Congress of 1881, affirming the necessity of experiments upon animals. To the ignorant accusation that physiological experiments had been and were of no use or influence in the advancement of medicine, the leaders of the profession unanimously affirmed that it is upon Physiology that Medicine and Surgery are based, and that there can be no real progress in those sciences without a corresponding progress in experimental Physiology and Pathology. The Association for the Advancement of Medicine by Research has been of the greatest possible value and assistance to Physiology in this country. It has shown physiologists that they have the great medical profession at their back, and it has acted as an impartial and independent medium of communication between physiologists and the successive Secretaries of State, whose business it has been to administer the Act.

(4) A fourth result of the attacks of the anti-vivisectionists has been, I may perhaps be permitted to believe, the re-establishment of this Section of Physiology of the British Association. Those who were present at the meeting of the Association in Nottingham may have remarked that the gutters of that town were strewn with papers which had been forced upon the members of the Association by the anti-vivisectors of the place. This literature, which in a double sense may be termed "gutter literature," teemed with flagrant misstatements, and with vicious calumnies, directed against physiologists, and especially called forth, I presume, by the fact that for the first time in the history of the British Association a physiologist was called upon to occupy the presidential chair. We may look upon the establishment of this Section as the reply of the Association to the false witness which was borne against us at Nottingham.

But although a special section for Physiology has been re-established, it may not be advantageous that there should be one at every meeting of the Association. Physiology is above all things a practical science. It requires laboratories and means of demonstration. Physiologists are rarely satisfied with the opportunity of hearing and reading papers, but require that, as much as possible, the actual methods of research employed should be capable of demonstration. By this I am not to be supposed to advocate the demonstration of experiments upon animals, for there are very many subjects in Physiology which can be both worked at and illustrated in a manner involving in no sense whatever the word vivisection. But in order that the methods should be shown, it is important to have the appliances of a laboratory at hand, and the Association frequently meets in towns which are not university towns, and have no laboratories, in which, therefore, it would be difficult or impossible to arrange for demonstrations of the sort that I am alluding to. On this account we may well imitate the practice of the British Medical Association, which establishes a Section of Physiology only when its meetings are held in such a centre as is likely by the applicances which are to be found in that centre to render the Section useful and efficient. Hence, in recommending the establishment of a Physiological Section, it is expressly reserved that the Section shall be held only at such future meetings as may seem to the council to be desirable.

I will now invite you to consider with me one or two of the more obscure subjects in the range of Physiology, subjects which are, however creating a great, almost an absorbing, interest at the present moment The first of these subjects relates to the structure and function of every cell in the body. All are aware that the body of every animal and of every plant is made up of minute corpuscles which are formed of protoplasm, and which contain in every case at least one nucleus. The protoplasm and the nucleus form the living substance of the cell. Other substances may be present, but they are, in a sense, outside the nucleus and protoplasm, not incorporated with their substance. Apart from a few details relating to the structure of the nucleus, this was, until quite lately, practically all that we knew regarding the parts composing either the animal or the vegetable cell. There appears, however, to be yet another something which, although in point of size is of very insignificant dimensions, yet in point of function may perhaps be looked upon as transcending in importance, in some respects, both the protoplasm and the nucleus. Not many years ago it was noticed by various observers that in certain specialised animal cells the protoplasm showed a tendency to radiate from or converge towards a particular point, and on further investigation it was found that at this point there was a minute particle. This observation, which began, as we have seen, upon specialised cells, was, after a little while, found to hold good for other and yet other cells, until, at the present time, we believe that in every cell of the animal or plant body such a particle exists Now, it may well be asked, why after all should so great importance be attached to this observation? To this it may be replied that, in the first place, it is of importance, because it shows conclusively that the whole cell is not of a uniform nature, since there is this one point within the cell that exerts a special attraction upon the rest of the cell-substance; and, indeed, on this account the particle has come to be termed the "attraction particle." And in the second place, because of the apparent universality of the occurrence of such a particle. And, thirdly, because of the fact that one of the most important phenomena exhibited by the cell hinges upon the behaviour of this particle; for it is found that before a cell or its nucleus divides this minute attraction particle begins by itself dividing, and is, in fact, more commonly met with double than single. Nor is it until the two particles thus produced have evolved, either from themselves or from the substance of the protoplasm or nucleus, a system of communicating fibres, the so-called *achromatic spindle*, that those changes in the nucleus and protoplasm take place which produce the division and multiplication of the cell. This *attraction particle*, which is also called the *central particle* or *centrosome*, has absorbed so great an interest that, short as is its history, many papers have already been devoted mainly to it, the latest of these being an elaborate treatise of some 300 pages by Martin Heidenhain. I shall not here attempt to follow out the details of all these researches, but will be satisfied with putting before you the conclusion which Heidenhain has come to regarding this particle, viz. "that it is morphologically, physiologically, and chemically a structure *sui generis;* not merely a separate portion of nucleus or of protoplasm, but an organ of the cell with definite functions, and having a definite existence of its own." Nevertheless, it is almost as minute an object as it is possible to conceive. In a cell which is magnified a thousand diameters the central particle appears merely the size of a pin-point. Yet this almost infinitely small object exerts an extraordinary influence over the whole cell, however large (and the cell may be many thousand times its size); for it initiates and directs those processes which result in the multiplication of the cell, and indirectly, therefore, it is concerned in directing the general growth of the individual, and ultimately the propagation of the species.

A former President of the Association took as the subject of his presidential address what he was pleased to call the "Next to Nothings." In considering this central particle, of the actual structure of which, and of its chemical constitution, we know at present hardly anything, we may surely regard it as a striking instance of the supreme importance of the "next to nothing" in Physiology.

The other subjects to which I desire to draw your special attention relate to the physiology of certain organs the functions of which have always been extremely obscure, and which, although they differ greatly from one another in almost every point of structure, and presumably also in function, it has been usual to group together under the name of ductless glands. The name "gland" is given to such organs of the body as take materials from the blood, and convey those materials in an altered or unaltered form, by a tube or duct, to a surface either internal or external. Such material is termed the secretion of the gland, and has for its object either the performing some function which is useful to the organism or the getting rid of material which would be detrimental if retained. In the case of the ductless glands there is no such possibility of pouring out material produced by the gland upon a surface, because these organs do not communicate with any surface by a duct; and whatever material they may furnish must therefore, if it is to reach the body generally, pass into the blood; that is to say, the blood on the one hand must furnish the materials for the secretion of the gland, and on the other hand it must take up those materials after they have been manufactured into something else, and carry them away to other parts of the body. Now, in the case of a certain number of the ductless glands there has not appeared to be any very great obscurity as to their function; for some of them seem very obviously to be devoted to the formation of corpuscles which are found within the blood itself. But with regard to others of these bodies it has not hitherto been possible to find any special material in the blood which they have furnished to it, and our knowledge of them is derived almost entirely from experiments. I will take the case of two of these to illustrate the vast influence which small and almost disregarded organs may exert upon the whole economy. But in the first place I may be permitted to point out what is indeed a self-evident statement, that there is no part of the body which does not exert some influence upon the rest. Every single portion of the body is continually taking materials from the blood, and furnishing to the blood other materials which are formed within it, whether we call that portion which performs such functions a gland or not; and it is quite certain that the removal of any portion of the body would be followed by some permanent alteration in the blood were it not that other similar parts may by increased activity compensate for the alterations which the blood would otherwise undergo from the loss of any one such part. Take the case of a limb. The changes which the blood undergoes in circulating through it affect the body generally through that fluid, for the composition of the blood becomes modified in traversing the limb. And not only is the body affected thus through the medium of the blood, but, by means of the nerves which pass to and from the limbs, the central nervous system is itself affected by the movements and alterations of various kinds which are proceeding in the muscles and other parts, and through the nervous system the whole organism must constantly be influenced from the limb. There is, however, no evidence that the removal of a limb or part of a limb permanently modifies either the condition of the blood or of the nervous system. Nor is such a result to be expected, for in this case there are other parts of the body possessing similar organs and performing similar functions, the increased activity of which may easily compensate for the loss which is sustained through removal of such a part.

But if we deal with an organ which is not multiple, but unique, and completely remove this from the body, it is easy to see that the case may be very different. This organ, like every other organ of the body, is continually taking from the blood some materials and giving up to it certain other materials. Now it is clear that its removal must make a permanent difference in the blood, and since the whole organism is remarkably sensitive to even slight changes in the composition of the circulating fluid, very marked results may well follow the removal of such organ. And this is in fact found experimentally to be the case.

It has long been known that extensive disease of the thyroid gland, a small reddish organ, weighing about one or two ounces, found at the front of the throat, is followed by extensive alterations in the nutrition of the body generally. The patient becomes swollen from the overloading of the connective tissues with a mucinous exudation; the nervous and muscular systems are seriously affected; the power of generating heat is greatly modified; and the final result is, in the first instance, the production of a condition of semi-idiocy, ultimately followed, if the disease be extensive, by death. Precisely similar results have been found in animals, and in fact in man as well, to follow the complete removal of this body. Yet the weight of this organ is not more than one sixteen-hundredth part of the whole weight of the body; and even this figure does not represent the enormous influence which a relatively small organ can exert upon the general nutrition of the body; for it is found that even if a minute part of the thyroid gland be left whilst the greater part is removed, the symptoms above enumerated do not supervene. Indeed, certain contradictory results which have been got by some observers after removal of the thyroid are explained by the fact that in some individuals there are minute detached particles of thyroid gland lying apart from the main organ; and that after the latter has been removed these detached particles may sufficiently carry on the function of the organ in relation to the blood and the nervous system to prevent the supervention of the deleterious symptoms which usually occur after its removal. Here is, then, a notable instance of the enormous influence exerted by a "next to nothing" upon the general organism.

Another illustration may be given from these ductless glands. It was noticed in 1849 by a celebrated physician, Dr. Addison of Guy's Hospital, that certain cases, accompanied by extreme debility, occurring in the human subject were associated with the appearance of peculiar bronzed patches on parts of the skin and mucous membranes; and on post-mortem examination of these cases, which always sooner or later have a fatal termination—and indeed sooner rather than later—he found the symptoms in question to be accompanied by disease and destruction of the supra-renal capsules—small bodies which are placed close to the kidneys, but which, so far as we know, have no physiological connection with them. Now when experiments came to be directed upon these bodies in order to elucidate their functions, and especially to observe whether their injury or removal was accompanied in animals also by symptoms similar to those occurring in man as the result of disease, it was found by Brown-Séquard that when these bodies are totally removed in any animal the removal is speedily followed by a fatal result. These experiments of Brown-Séquard's were made in 1858, and at the time attracted some attention. They were repeated by other experimenters with similar effects. But some of those who removed the supra-renal capsules obtained contrary results, and for many years the matter remained in an undecided condition. It was even supposed that the fatal results which were got by Brown-Séquard might be due to the shock of the operation or to the fact that the removal necessarily involves certain parts of the sympathetic nervous system, and were not necessarily due to the removal of the supra-renals. Recently, however, attention has been again directed to the subject, and the experiment of Brown-Séquard has been repeated by Tizzoni (1889) and by Abelous and Langlois (1891 to 1894) in various animals, viz. frogs, guinea-pigs, rabbits, and dogs. I have myself performed two confirmatory experiments in monkeys. The result of all these recent observations is to show that the complete removal of the supra-renal capsules is not compatible with prolonged existence of life, and Abelous and Langlois have shown that it is accompanied by an alteration in the blood, which renders that fluid poisonous to other animals. The contrary results which have been obtained by some investigators are apparently due to the fact that in certain cases there are, as with the thyroid body, small isolated portions of supra-renal substance ("accessory capsules," as they are sometimes called) which have not been noticed and removed at the time of the operation, and that these small portions of supra-renal substance have served to maintain that proper relation between the blood and the gland which is sufficient to prevent the supervention of the symptoms in question.

Now the weight of both supra-renal capsules taken together is not more than three drachms, and their weight, as compared with that of the whole body, is only as 1 to 6000 or less. The accessory supra-renal capsules which may be left after the removal of the main bodies probably do not originally weigh more than one-twentieth of the whole structure, and yet this minute proportion of material (a material, so far as we know, unique in the organism) is nevertheless sufficient to maintain the composition of the blood and the nutritive equilibrium of the body, and thus to prevent the necessarily fatal result of complete removal.

Now it has been found in the case of the thyroid gland that patients in which this structure has been so diseased that its function is seriously interfered with, and animals in which it has been removed entirely, may be greatly benefited, if not indeed cured, by the inception, either subcutaneously or with food, of the thyroid glands of animals, or of the juice of such glands. Even where no affection of the thyroid can actually be detected, the exhibition of thyroid juice is frequently beneficial in certain conditions of the system, and it was noticed by Dr. Oliver, of Harrogate, that this is especially the case where there is a too marked constriction of the blood-vessels, the juice of this body tending in such cases to reduce the extreme tone of the vascular walls, which is the cause of this condition. Encouraged by this result, Dr. Oliver was led to examine the effects of other animal extracts, and among them that of extract of supra-renal capsule. The effect of this was precisely the reverse of that which he had got with the thyroid body, for he obtained evidence tending to show that in certain cases in man extract of supra-renal capsule can produce an *increase* of vascular tone and a diminution in the size of the arteries. Beyond this point, however, Dr. Oliver was unable to proceed by clinical experiment, and he accordingly came to my laboratory with the object of determining the precise physiological effect of the active substance of the capsules. The results which were obtained show that there is present in both alcoholic and watery extracts of the gland a most potent physiological substance which when injected into the body of an animal produces, even in minute doses, a remarkable effect upon certain parts of the nervous system, upon the muscular system, upon the heart, and upon the blood-vessels. If only as much as a grain by weight of supra-renal capsule be extracted with alcohol, and if this alcoholic extract be allowed to dry, and then be redissolved in a little water or salt solution and injected into the blood of a dog, the results which are obtained, considering the minute amount of substance added to the blood, are certainly most extraordinary. The nervous centre which regulates the action of the heart is powerfully affected, so that the heart either beats very slowly and weakly, or the auricles may even for a time stop beating altogether. If, however, these inhibitory influences be cut off by division of the vagi nerves, the effect of the poison upon the heart is of an opposite character. There is great acceleration of the rate of the beat and a great increase of force. This is accompanied by a strongly marked influence upon the blood-vessels, and especially upon the arterioles. The walls of these are chiefly muscular, and the drug exerts so powerful an action upon this muscular tissue as to cause the calibre of the vessels to be almost obliterated. The heart being thus increased in force and accelerated, and the calibre of the vessels almost obliterated, the result is to raise the pressure of the blood within the arterial system to an enormous extent, so that from a blood-pressure which would be sufficient to balance a column of some four inches of mercury the pressure may rise so high as to be equal to a column of mercury of twelve or more inches.

This result is obtained, as we have seen, by a very minute dose. We have to do here with a substance which is as potent, although in a different direction, as strychnia. Whether it is a useful substance formed by the supra-renals from materials furnished by the blood, and subsequently gradually used in the economy for the virtue of its action upon the circulatory system, or whether it is to be regarded as a poison, formed by the tissues during their activity and carried by the blood to the supra-renals, there to be rendered innocuous, we do not as yet certainly know. These are important points which must form the subject of further investigation. But, however this may be, it is clear that in this gland also we again meet with an instance of the physiological importance of what Sir Frederick Bramwell called the "next to nothing."

I will give one more instance, taken this time from a gland which is provided with a duct. Until quite recently it might have been thought that there was nothing very obscure regarding the functions of the pancreas. The pancreas is a digestive gland which lies below and behind the stomach: it has a duct which carries its secretion into the beginning of the intestine, and that secretion acts powerfully upon all constituents of the food, digesting starch, meat, and fat. It was not supposed that the pancreas had any other function to perform. Animals can live without this secretion, and to a large extent can continue to digest and absorb their food much as before; for it has been possible to divert the secretion from the intestine and to collect it at the surface of the body; and it is found under these circumstances that, although the food is not quite so readily digested, nevertheless the animal does not materially suffer from the lack of the secretion. It was discovered, however, a few years ago (by v. Mering and Minkowski) that if, instead of merely diverting its secretion, the pancreas is bodily removed, the metabolic processes of the organism, and especially the metabolism of carbohydrates, are entirely deranged, the result being the production of permanent diabetes. But if even a very small part of the gland is left within the body, the carbohydrate metabolism remains unaltered, and there is no diabetes. The small portion of the organ which has been allowed to remain (and which need not even be left in its proper place, but may be transplanted under the skin or elsewhere) is sufficient, by the exchanges which go on between it and the blood generally, to prevent those serious consequences to the composition of the blood, and the general constitution of the body which result from the complete removal of this organ. Now, some years ago it was noticed by Kühne and Sheridan Lea that, besides its proper secreting structure composed of tubular alveoli, lined by granule-containing cells, there are highly vascular patches of peculiar epithelium-like cells scattered here and there in the substance of the pancreas, which are wholly unconnected with the ducts and, so far as one can judge, with the secretion of the gland. We do not know anything whatever about the function of these patches, although from their vascularity it is extremely probable that they are not without importance physiologically, and it is tempting to conjecture that it is these cells which are specially concerned in effecting that influence upon the metabolism of carbohydrates which experiment has shown to be peculiar to the pancreas.

The lesson to be drawn from these results is clear. There is no organ of the body, however small, however seemingly unimportant, which we can presume to neglect; for it may be, as with the supra-renal capsules, the thyroid gland, and the pancreas, that the balance of assimilation and nutrition, upon the proper maintenance of which the health of the whole organism immediately depends, hinges upon the integrity of such obscure structures; and it is the maintenance of this balance which constitutes health, its disturbance, disease. Nor, on the other hand, dare we, as the investigation of the attraction-particle has shown, afford to disregard the most minute detail of structure of the body.

> "All is concenter'd in a life intense,
> Where not a beam, nor air, nor leaf is lost,
> But hath a part of being."

PHYSICS AT THE BRITISH ASSOCIATION.

AFTER the President's address on Thursday morning, Lord Kelvin opened the proceedings in Section A with an account of some preliminary experiments made by himself and Mr. Maclean on the electrification of air by the subtraction of water from it. The subject is one in which Lord Kelvin has been for many years interested, and he commenced experimenting on it as far back as 1868. The nature of the results now obtained was illustrated by his insisting that the proper title of the paper was "Preliminary experiments *to find if* subtraction of water from air electrifies it" (and not as in the *Journal*—"Experiments *proving* the electrification of air"). In the present investigation a large U-tube was used. One branch of this was filled with pumice-stone soaked in sulphuric acid; the other was simply varnished inside and out. By means of a platinum wire touching the pumice, connection was made with a quadrant electrometer. A metal cylinder screened the tube from external influence. Air from an ordinary blow-pipe bellows was blown through the tube steadily for an hour; and the electrometer showed an electrification rising gradually to about nine volts positive. This shows that the passage of the air through the tube gave positive electricity to the acid, and therefore sent away the dried air electrified negatively. No such effect was observed when the pumice was moistened with water instead of sulphuric acid. The experiments are to be repeated with precautions to prevent any bubbling of the air through liquid in the tube; for it was observed that the strong positive electrification of the tube (when acid or calcium chloride was used) seemed to commence suddenly as soon as a gurgling sound, due to bubbling through free liquid, began to be heard. The authors have reversed the conditions, and have first dried air by passing it over sulphuric pumice, and then passed it through a tube containing moistened pumice. The tube became negatively electrified, but this may have been due to the negative electrification of the dry entering air. This experiment is to be repeated with dried and dis-electrified air. Lord Kelvin also described certain preliminary experiments made by himself and Mr. Galt with the object of comparing the discharge of a Leyden jar through different branches of a divided channel. The metallic part of the discharge channel was divided between two wires of conducting metal, each consisting in part of a test-wire. Each of the two test-wires consisted of 51 cm. of platinum wire of 0·006 cm. diameter and 12 ohms resistance stretched in a glass tube. One end was fixed to a solid brass mounting, and the other was attached to a fine spring carrying a light arm for multiplying the motion. The testing effect was the heat developed in the test-wire by the discharge, as shown by the elongation, the amount of which was measured by a tracing on sooted paper carried by a drum. The wires to be tested were generally of the same length. When they were of the same material but of different diameters, the testing elongation showed, as might be expected, that the test-wire in the branch containing the thicker wire was more heated than the other. With wires of various non-magnetic materials, of the same resistances but different lengths and diameters, the testing elongations were very nearly equal. In one experiment two equal copper wires were used, but one of them was coiled into a helix; the testing elongation in this branch was less than half of that in the straight branch. Lastly an iron wire was compared with a platinoid wire of equal resistance but greater diameter. The heating effect in the platinoid branch was nearly one-and-a-half times as great as in the iron branch. This is interesting in relation to Lodge's experiments on alternative paths, which were not decisive in showing any general superiority of copper over iron of the same steady ohmic resistance, but even showed a seeming superiority of the iron for efficiency in the discharge of a Leyden jar.

Prof. Oliver Lodge followed with a communication on "photo-electric leakage." It is known that a negative charge on an electrified surface escapes much more rapidly when the surface is illuminated with ultra-violet light (Hallwach's experiment). Prof. Lodge has investigated the rate of discharge for a number of substances under positive as well as negative electrification, and in hydrogen as well as air. He finds that when the inside of an electrified pewter-pot is illuminated, it does not leak; but when the edge is illuminated, it leaks rapidly. Thus the leakage appears to be a matter of surface-tension, and not of potential. In the discussion which followed, Prof. S. P. Thompson stated that he had verified the statement made by Elster and Geitl, that when the light is polarised the effect depends upon the plane of polarisation, the leakage being most rapid when the Fresnellian vibrations are in such a direction as to "chop into" the surface. He has found an analogous difference in the action on selenium cells.

Mr. G. H. Bryan presented the second part of his report on the present state of knowledge in thermodynamics. In a lengthy and valuable paper he discusses the limitations to the law of distribution of energy in the kinetic theory. He deals primarily with the so called Boltzmann-Maxwell law of distribution of energy among the molecules of a gas, which law forms the basis of the kinetic theory of gases. One of the main points kept in view has been to show, as far as possible, where to draw the line between dynamical systems which do, and dynamical systems which do not satisfy the law in question. A great advance in the subject is due to the extension of the use of generalised co-ordinates, by which greater generality has been given to results, and the analysis has been much simplified, as a comparison of Boltzmann's early papers with modern writings abundantly testifies. A further simplification has been effected by the extensive use of the Jacobian notation in this report. The report is divided into three sections. In Section I. the law is regarded in the aspect of a general dynamical theorem without reference to any particular applications, and without taking into account the effect of collisions. Section II. treats of its application to a system of bodies colliding with one another indiscriminately, and partaking of the nature of gas molecules. Section III. deals briefly with certain researches relating to the connection between the Boltzmann-Maxwell law and the Theory of Probability, the Virial Equation, and the Second Law of Thermodynamics. With regard to non-colliding systems (Section I.), it may be asserted that a large portion of our progress has been made in, firstly, showing that Maxwell's demonstrations are faulty and unsatisfactory, and by subsequently discovering fresh methods of proof, which, while leading to the same general conclusions, show more clearly the limitations and conditions under which these conclusions hold good. Test cases of Maxwell's law are given, and also an account of Mr. Culverwell's criticism of the "decisive" test case by which Lord Kelvin claims to have effectually disposed of the law. It is urged that uniformity of nomenclature is most desirable in this as in other branches of science, and hence that some definite understanding should be agreed on as to what precisely constitutes the Boltzmann-Maxwell law. The following statements are recommended:—(1) That the distribution of a large number of molecules or other dynamical systems of the same or different kinds in which the coordinates (q) and momenta (p) of each system are so arranged that the number of systems in the neighbourhood of any given state is proportional to

$$e^{-hE}dp_1 \;.\;.\;.\;.\;.\; dp_n dq_1 \;.\;.\;.\;.\;.\; dq_n,$$

h being the same for all the kinds of molecules or systems, be called the Boltzmann-Maxwell distribution. (2) That the law which asserts the permanence of the Boltzmann-Maxwell distribution in any particular case be called the Boltzmann-Maxwell law. (3) That in future these names be not applied to any corollaries such as that which asserts the equality of the average value of the squares into which the kinetic energy can be split up. That corollary may be called Maxwell's law of partition of kinetic energy.

The proof of the Boltzmann-Maxwell law, and the assumptions involved in it, may now be regarded as fully satisfactory for gases whose molecules collide with one another to a certain extent at random, but in a medium in which the molecules can never escape from one another's influence the subject still presents very grave difficulties.

On Friday the Section held a joint meeting with Section G, at the headquarters of the latter in Keble Hall. The first sub-